

DIFFERENCES IN SIZE AND DEPTH FOR TWO MORPHS OF
DIAULULA SANDIEGENSIS (COOPER, 1863)

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Diaulula sandiegensis (Cooper, 1863) has long been known to vary in dorsal coloration, with a ground color ranging from cream to dark brown, overlain by either rings or irregular blotches (Behrens, 1991; Smith & Carlton, 1975). Some morphs previously considered to be separate species (*Diaulula* sp. 1, *Doris* s. l.) have recently been combined into *D. sandiegensis* (Behrens & Valdés, 2001; Behrens, 2004). However, other morphs may actually be separate species (Dayrat, 2010). I investigated whether morphs common in British Columbia showed consistent differences in size or depth of occurrence.

There are at least two common forms, though each shows variation in characters, and some individuals are ambiguous in their markings (Table 1, Fig. 1). The “ring” form has few brown rings symmetrically distributed and offset from the midline, typically on a light background (Fig. 1A). These rings may be complete or broken and relatively light or dark. The “spotted” form has multiple, irregular, dark patches similar to leopard spots in that they are surrounded by a ring of different (in this case, lighter) value, and they often grade into this color towards the center. These spots are often asymmetrically

distributed on a background that is darker than both the outer ring and the outer mantle edge (Fig. 1B). The spotted pattern seems more frequent in the northern parts of its range, for example, in Washington and British Columbia (MacFarland, 1966; Morris et al., 1980; McDonald, 1983; Dayrat, 2010) and may be reflected in the common names given in guidebooks: those from California often list the species’ common name as “ring-spotted doris” (Morris et al., 1980; Ricketts et al., 1985), whereas those from the northern part of the range often use “leopard doris” (Harbo, 2011; Lamb & Hanby, 2005).

Diaulula sandiegensis were collected for other studies from February 1998 through August 2000 (Penney, 2008, 2013) by hand from the intertidal zone or using SCUBA, in Barkley Sound near Bamfield, British Columbia, Canada. Collection was haphazard with respect to size or dorsal pattern, but no ambiguous individuals were encountered. Three field sites contributed the most animals: Scott’s Bay (48°50’06”N, 125°08’48”W), Dixon Reef (48°51’24”N, 125°07’06”W) and the west side of Seppings Island (48°50’30”N, 125°12’30”W). Nudibranchs were kept in flowing, natural seawater at Bamfield Marine Sciences Centre

TABLE 1. Characters associated with *Diaulula sandeigensis* morphs. Characters listed are for typical forms; individuals may vary in the consistency of characters. “Halo” means an area lighter than the ground color of the dorsum.

Character	Ring	Spotted
Form of marking	Ring, open in middle	Spot, closed or gradient to ground color in middle
Number of markings	4–10	> 10
Size variation among markings	Little	Great, large spots > 5x diameter of small
Distribution of markings	Symmetrical	Asymmetrical
Markings on midline	No	Yes
Halo around markings	No	Yes
Central dorsum darker than edge	No	Yes

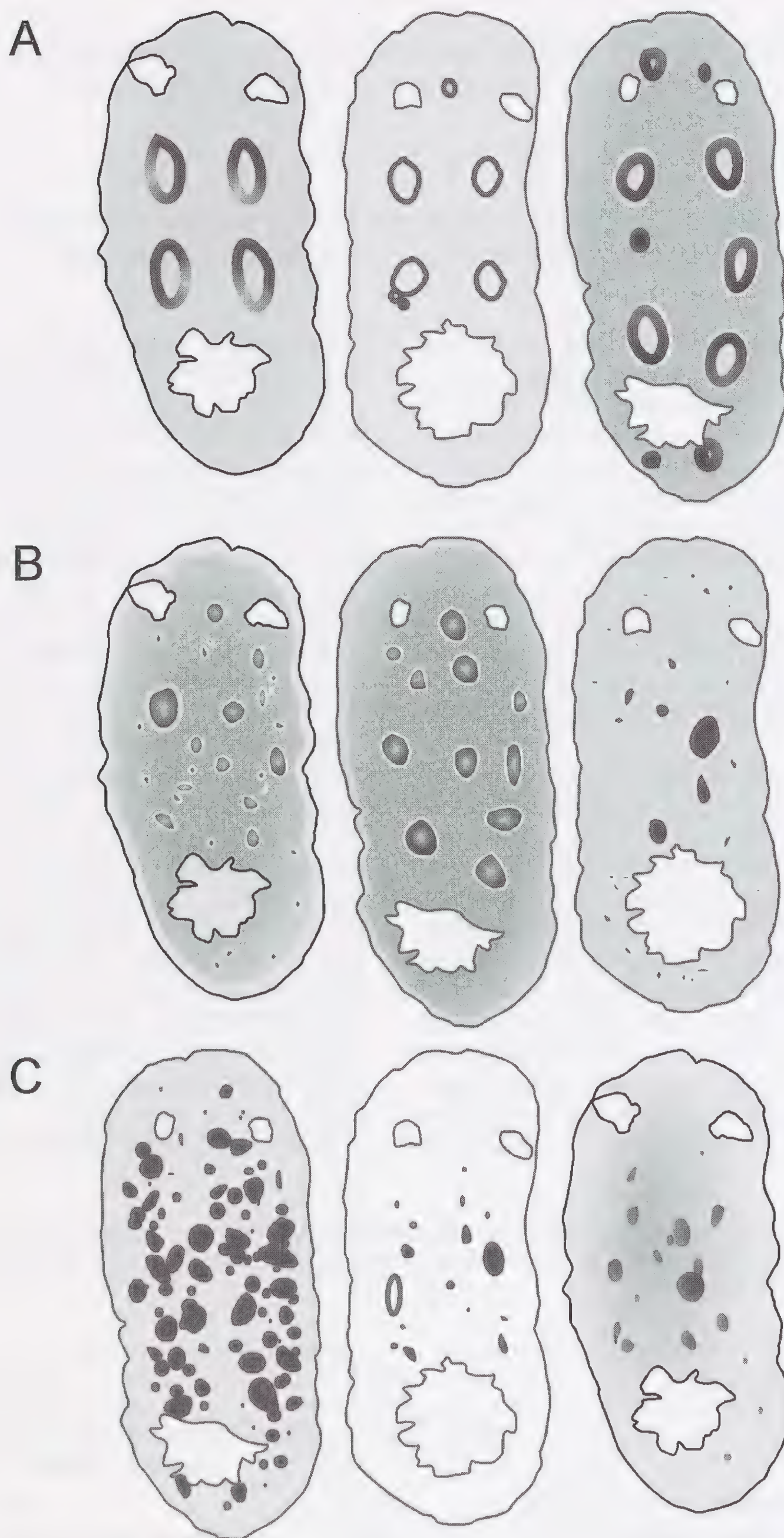


FIG. 1. Diagrams illustrating pattern differences between and variation within morphs of *Diaulula sandiegensis*. A: Ring form; B: Spotted form; C: Ambiguous: not clearly ring or spotted. Rhinophores and gill are colored white to distinguish from mantle patterns. See Table 1 for characters.

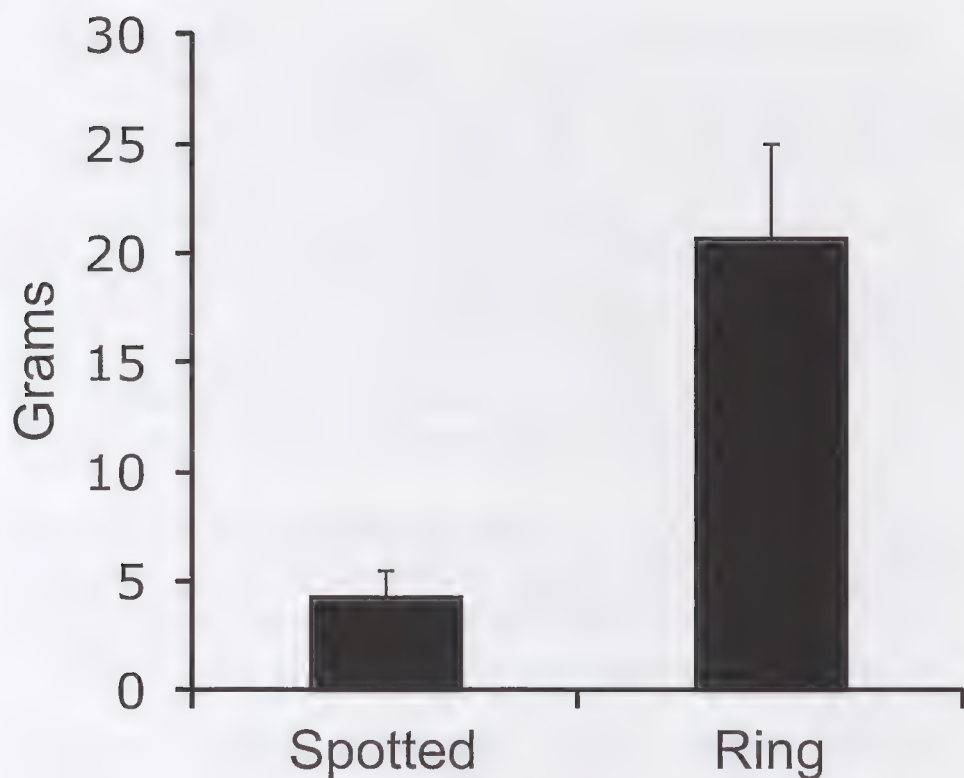


FIG. 2. Size differences between morphs of *Diaulula sandiegensis* in Barkley Sound, British Columbia.

until weighed, within three days of collection. For measurements, all animals were brought from sea table to the laboratory in their resident container. Individuals were scored as “ring” or “spotted” as defined above, damp dried on a paper towel then immediately transferred to a tared weigh boat on a calibrated digital balance.

The two morphs differed in size: spotted forms averaged 4.4 g compared to 20.8 g for ring forms (T-test, $n = 37$, $p < 0.0001$; Fig. 2). Restricting this analysis to just Scott’s Bay – the only field site where both intertidal and subtidal animals were collected – gave an equivalent result (2.4 vs. 30.2 g, T-test, $n = 22$, $p < 0.0001$). There is

some overlap in the size range for the morphs: the maximum mass found in spotted forms was 8.5 g, and two specimens of the ring form were below this weight (5.1 g, 8.1 g). Ricketts described specimens from Sitka similar to the spotted form (“darker in color, gray brown”) but larger than Monterey specimens like the ring form (Ricketts et al., 1985: 66), so size differences may depend on site and food available.

The two morphs also differed at the depth at which they were found, with spotted forms predominantly intertidal and ring forms exclusively subtidal (Fisher’s Exact Test, $n = 37$, $p < 0.0001$; Fig. 3). Again, restricting the analysis to Scott’s Bay specimens did not change the pattern (Fisher’s Exact Test, $n = 22$, $p = 0.001$). Spotted individuals were sometimes found subtidally, but no ring forms were found in the intertidal zone in this study or in over six years of observation (1997–2002). Previous studies have concluded that *D. sandiegensis* from bays are darker colored than those from open coastal waters (McDonald, 1983), and I found more of the spotted forms at Scott’s Bay than the more open waters of the Dixon Reef or Seppings Island sites. I have also found the spotted forms in protected waters at Friday Harbor, Washington. Morris et. al. (1980) noted that *D. sandiegensis* is primarily subtidal in the south and intertidal in the north of its range; instead, a spotted, intertidal morph might be primarily present in the north. Diets of the ring forms have been characterized (Penney, 2013), but similar data are not available for spotted

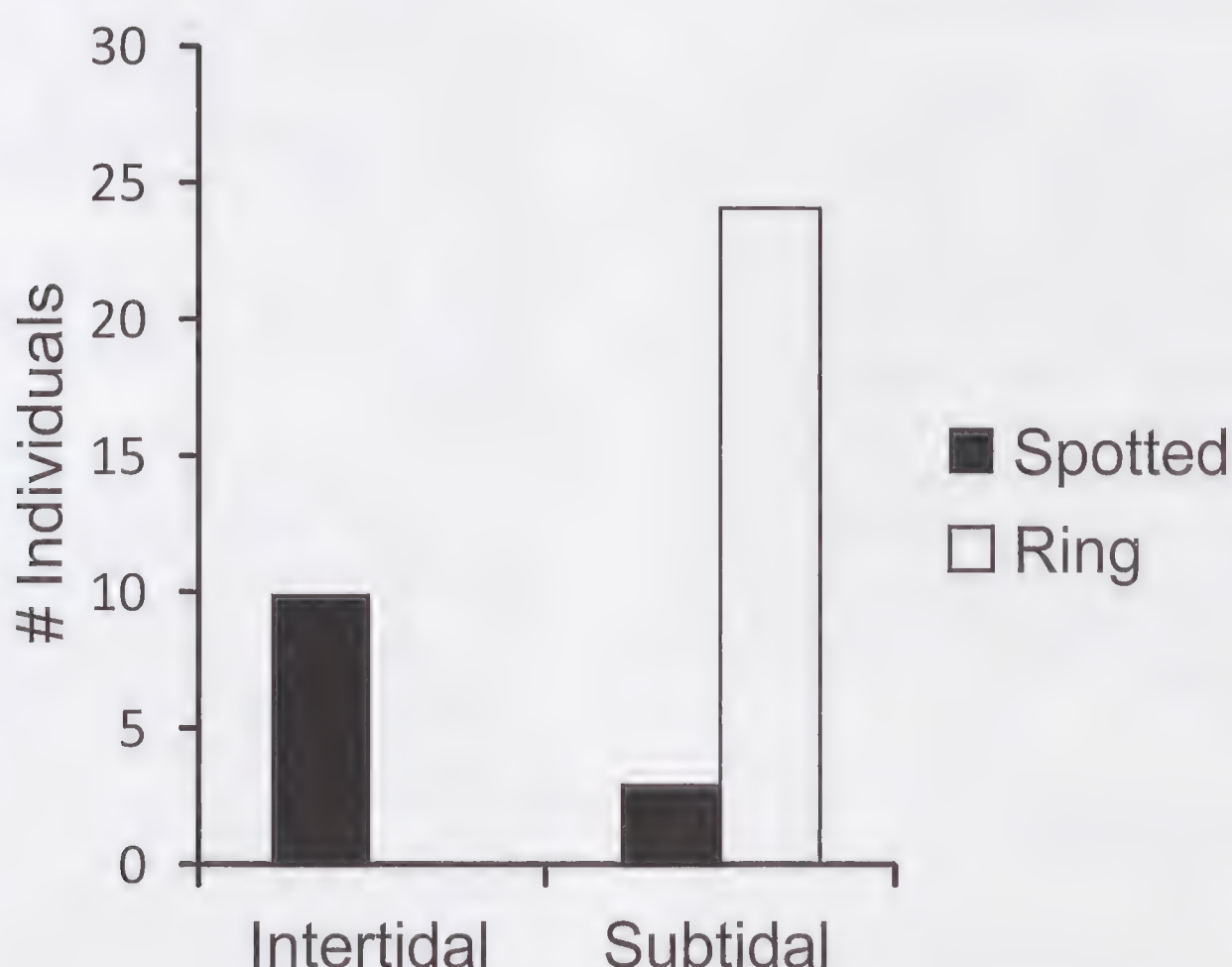


FIG. 3. Association of morphs with depth at sites in Barkley Sound, British Columbia.

forms. Intriguingly, *D. sandiegensis* chemistry also varies from north to south (Kubaneck & Andersen, 1999), although the investigators did not record dorsal pattern.

Behrens & Valdés (2001) found there were no internal anatomical differences among the *D. sandiegensis* specimens they analyzed, but the spotted form likely was not included in their analysis. They only dissected one specimen from north of California, where the spotted form would be common (Valdés & Gosliner, 2001), and this specimen was taken subtidally, where the ring form is most common. One of their pictured examples does fit the spotted pattern (Fig. 2E; Behrens & Valdés, 2001) but was not among the specimens dissected. Another of their specimens (Fig. 2F; Behrens & Valdés, 2001) is not clearly a spotted form or leopard form. A survey of photos available on the internet reveals several other ambiguous individuals (Fig. 1C), suggesting characterization of morphs is incomplete.

These differences in color, habitat, size and chemistry could also arise by intraspecific variation, but there are enough correlated differences between the morphs that mating or genetic studies should be used to test whether these represent separate species. Likewise, *Cadlina laevis* (Linnaeus, 1767) may also be two species specialized to different depths and prey (Rudman & Bergquist, 2007). Such cryptic species complexes of nudibranchs may prove a fruitful area for research.

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